

Mechatronics Engineering at the University of Waterloo

Presented by:

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Key Components of UW Mechatronics Education Program

Program design drivers

A dedicated u/g program in Mechatronics engineering education with emphasis on experiential learning, electromechanical design and hands-on training through projects and co-op placements

Balance between theory and applied work

Students complete eight academic terms and no less than five co-terms as part of the degree requirements. The last two terms are mostly made up of technical electives and an eight-months capstone sequence.

Impact of the Program

Examples of Learning Outcomes

- Enterprise co-op and venture creation after capstone project.
- Program threads which include courses that span multiple terms to target learning outcomes related to use of engineering tools, knowledge base, design and teamwork.

Balance between new mechatronics courses and related traditional courses

- The program has a balanced curriculum with subjects from Mechanical, Electrical, Systems Design and software engineering.

Impact of the Program

Balance between new mechatronics courses and related traditional courses (Cont'd)

- ❑ New specialized courses are introduced as technical electives in third and fourth years to provide in-depth knowledge in one or more areas of specialization in Mechatronics.
- ❑ Also, we have several options which can be completed in parallel to the major in Mechatronics engineering. Popular options are in Management Sciences, Physical sciences, kinesiology and software engineering.

Impact of the Program

Change in the level of burden on faculty

With expansion of the Mechatronics program at UW, another stream was added in 2014. This translates into 44 additional courses per year at steady state. With a normal teaching load of 3 courses per TT/faculty members, 13-14 new positions were added to meet the need to cover these teaching tasks.

Impact on research or consulting outcomes for faculty

The normal breakdown of activities per faculty members is 40% teaching, 40% research and 20% service. This offers a good balance between teaching and research for most faculty members. In consultation with the Chair, split between teaching and research can be revisited to accommodate research chair for example.

Impact of the Program

Space and other Resources

- ❑ Mechatronics engineering education requires development of a curriculum rich in laboratory modules and hands-on training. An u/g mechatronics education program hence requires major allocation of space resources and human resources (lecturers, teaching assistants, admin. for counseling/scheduling/etc).
- ❑ The TA budget allocation per year in our funding model makes it challenging to create enough sessional positions per year (needed given sabbatical and other leaves) and maintain a student/TA ratio of 30/1 in tutorials and lab sessions.

Impact of the Program

Frameworks for program development from institution to institution

- ❑ Some programs place emphasis on one or more aspect of Mechatronics engineering throughout the curriculum, e.g., software, Robotics or autotronics.
- ❑ This is closely tied to existing resources in terms of lab space, expertise of faculty members contributing to the teaching in the program and feedback from industry partners (if applicable)

Essential skills for Mechatronics

- ❑ **Sensors and actuators:** concepts, sensing and instrumentation, signal processing and multi-sensor data fusion, machine elements, electromechanical machine design and power & drives
- ❑ **Mechatronic programming:** basic programming in C and Python, data structures, H/W interfacing, numerical methods and simulations
- ❑ **Control:** PLC control, linear systems, linear feedback control and digital control for dynamic systems.
- ❑ **Software** C, LabVIEW, MATLAB, Python and CAD

Essential skills for Mechatronics (Cont'd)

- ❑ **Traditional electrical and computer engineering courses:** electric circuits, sensors, power electronics, interfacing and analog design.

Program Accreditation

Has your institution faced challenges in accreditation for an undergraduate mechatronics program?

- CEAB accreditation twice in 2007 and 2013. Both focused on AU delivered through the minimum path for degree completion.
- The AU units are assessed in Natural Science, Engineering Design, Engineering Science, Mathematics and Complementary studies.
- Mechatronics programs tend to be borderline in terms of minimum required AU for Natural Science to satisfy CEAB accreditation requirements.

Program Accreditation

Has your institution faced challenges in accreditation for an undergraduate mechatronics program?

- ❑ In the next accreditation visit, the program will be evaluated using the CEAB outcome based assessment method which focus on demonstration of 12 learning outcomes with similarities to the ABET curriculum assessment approach.
- ❑ Rubrics which define performance indices for each of the CEAB learning outcomes are used to gather program data to demonstrate that the curriculum targets all learning outcomes through delivery of program specific knowledge and training.

Program Accreditation

Emerging best practices

- ❑ Strong ties with industry to create internship and co-op opportunities for students during non-academic terms.
- ❑ UW has a large co-op mobility program and this model is an integral part in engineering education at our University.

Alignment with Industry Needs

How is your program reflecting the methods and tools of industrial applications?

- Strong ties with Industry: automotive, manufacturing, IT, software and mining. These ties also extend to collaborative research between our faculty and many of the industries which employ our students.
- This provides our faculty members to introduce new methods and tools applied in industry for training in the classroom, i.e., labs which cover additive manufacturing methods, MEMS fabrication of sensors, CFD methods for modeling aerodynamic flow, FEM methods, etc

Alignment with Industry Needs

Balance between theoretical/abstract concepts and industry relevant applications

- ❑ Many of the capstone projects originate from our UWAFT, Midnight Sun, Robotics and Formula Hybrid teams. Each of these teams receive sponsorship for industry in the form of funding and hardware for projects and competitions.
- ❑ Industry partners include Denso, GM, QNX, Honda, Google, Microsoft, Shell, Quanser, SUMMO, etc. Hence, the capstone projects involve design and prototyping with emphasis on systems for industrial applications.

Alignment with Industry Needs

Balance between the skills to effectively use modern tools and the ability to think and manage mechatronics system complexity

- We are able to achieve this balance between hands-on training and education through the impressive lab facilities we have to service our u/g courses; Fred Church Lab, WEEF Lab, WatIMake, SDC, student machine shop and the MTE capstone design studio.

Continual Improvement of the Program

What has the general response been from your students? Their employers?

- Very positive. Our program has an excellent reputation and our students are sought after by industry in US, Canada and across the Globe.
- Our graduates achieve great success in industry as lead engineers, scientists and entrepreneurs.

Continual Improvement of the Program

What mechanisms do you employ to get the feedback, etc.?

- Students exit surveys
- Employers co-op evaluations of work term reports and
- Industry judges of capstone project prototypes.

Do you think there should be a comprehensive framework for industry to provide feedback into your programs?

Yes. However, no formal mechanism currently in place to do so. Curriculum contents are revisited every year and contents redesign in courses happen periodically.